TABLE 8.—*Correlation coefficient between rainfall and run-off, Wagon Wheel Gap experiment, Watershed A*

Year	Run-off—X	Rain-fall—Y	x	y	x^2	y^2	xy +	xy −
1912	7.57	25.67	+1.37	+4.24	1.88	17.98	5.81	
1913	4.64	17.86	−1.56	−3.57	2.43	12.74	5.57	
1914	5.61	20.84	−.59	−.59	.35	.35	.35	
1915	5.33	21.94	−.87	+.51	.76	.26		0.44
1916	5.87	20.04	−.33	−1.39	.11	1.93	.46	
1917	9.47	27.25	+3.27	+5.82	10.69	33.87	19.03	
1918	3.04	14.19	−3.16	−7.24	9.99	52.42	22.88	
1919	6.18	24.29	−.02	+2.86	0	8.17		.06
1920	7.97	24.20	+1.77	+2.77	3.13	7.67	4.90	
1921	6.91	20.79	+.71	−.64	.50	.41		.45
1922	6.84	22.23	+.64	+.80	.41	.64	.51	
1923	6.23	20.06	+.03	−1.37	0	1.88		.04
1924	6.95	23.37	+.75	+1.94	.56	3.76	1.46	
1925	4.15	17.32	−2.05	−4.11	4.20	16.89	8.43	
Mean	6.20	21.43			2.50	11.355	69.40 −.99	.99
							+68.41	

$$(2.50)^{\frac{1}{2}}=1.58=\sigma_x \qquad r_{xy}=\frac{+68.41}{14\times1.58\times3.37}=+0.9174$$

$$(11.355)^{\frac{1}{2}}=3.370=\sigma_y \qquad b_{xy}=\frac{0.9174\times1.58}{3.37}=0.430$$

$$b_{yx}=\frac{0.9174\times3.37}{1.58}=1.955$$

Regression equations:
(I) Run-off=0.43×rainfall−3.01.
(II) Rainfall=1.955×run-off+9.31.

CONCLUSIONS

The subject matter discussed is the result of special study, in the search of a better understanding of the problem. Having constant use for rainfall and run-off data, the writer has felt that the work of previous investigators has carried a solution only part way. It is contended that their difficulty has lain partly in the fact that the nature of the lag of run-off behind rainfall has not been sufficiently considered. A higher state of agreement seems to result, in every case that has been tried by the writer, *when* some lag is given to the run-off. The amount of this lag, as given in the examples cited, may be open to greater refinement and may be derived by more elegant methods. It may be given different values and still not vary the average results of computed values very much. For example, in the case of the Yadkin River, the lag of four months was adopted and the correlation coefficient found, considering the years 1903 to 1909, inclusive, and the year 1912. The coefficient was +0.8988. If now, in addition to the years above, we take the years 1914 to 1919, inclusive, making 14 years in all, and take a lag of 2½ months only, the correlation coefficient comes out at +0.9061 (about the same figure, although slightly higher); and the computed results differ very little from those in Table 3 (the average). However, if *no* lag is given the run-off, the correlation is very small.

Variation in temperature and wind movement must have considerable effect upon the amount of rainfall that is responsible for the mainstay of the stream's flow. Attempts to include consideration of these factors in the Wagon Wheel Gap data have led nowhere up to the present. Run-off seems to be roughly inversely proportional to wind movement and temperature, and these two latter variables display considerable change in value in the Wagon Wheel Gap data. Their influence may be the missing link of some 11 to 12 per cent that we seem to lack in the correlation coefficient. It is the hope of the writer that this article may provoke further study leading to a complete and elegant solution.

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RAINFALL PERSISTENCY AT SAN JUAN, P. R.

551.578.1 (729.5)

By C. L. RAY

[Weather Bureau, San Juan, P. R., April 22, 1929]

The following notes relating to rainfall persistency at San Juan, P. R. were suggested by an original study of Besson, an abstract of which appeared in the MONTHLY WEATHER REVIEW, June, 1924, page 308,[1] "On the Probability of Rain (at Montsouris near Paris)." The factor of persistency or the tendency of rainfall to repeat itself for 1, 2, 3, or a greater number of consecutive days, was found to be markedly higher than the general probability, or in other words, the probability independent of what took place the day before. For example, at Monsouris the general probability for rain is 0.525. In a 50-year record there were 9,580 rainy days out of a possible 18,261, while there is an increase of 18 per cent or to 0.704 in the probability of a continuation of rain on a second day. There is also a gradual increase in the probability up to and including 15 days of rain and except for a short lapse a further increase for the higher groups. A similar study by Blair[1] based upon 30 years' records at Lincoln, Nebr., shows much the same effect of the persistency factor. At this station a general probability of 0.394—4,312 days of rain out of 10,956 possible is followed by an increase to 0.540 for a second day, or 14 per cent, and a gradual rise in values in consonance with the increase of consecutive days of rain.

In the present paper we have taken as a basis the 29-year-record at San Juan, P. R., comprising 6,205 rainy days out of 10,585 possible, for a general probability of 0.586. In Table 1 are given the total of single or separated days of rain, and the number of groups of 2, 3, 4, 5, etc., consecutive days upon which precipitation occurred. In the same table is shown the calculated days of rain (the number that would be expected) derived from the equation of general probability. The actual cases with rain exceed the calculated where more than 5 days are considered but are less where 1, 2, 3, 4, or 5 days is the factor. Thus we have a first indication of the part played by a markedly long series of daily showers at San Juan, which as

[1] Besson: Vol. 52, Mo. Wea. Rev., p. 309. Blair: Vol. 52, Mo. Wea. Rev., p. 350.

a rule are of short duration though commonly at an excessive rate. Of the total of rainy days nearly 67 per cent occur in groups of 5 days or more with 2 cases of exceptional length, the one with 25 days consecutive days and the other with 44 days, exceeding the Biblical 40 days and 40 nights, though in the present instance nocturnal precipitation is of generally greater frequency during at least 9 months of the year, including the fall and winter period in which the 44-day record occurred.

From data in Table 1 we compute the probability of rain where it is known to have rained the day before, using the equation in which S equals the number of groups of consecutive rainy days, K, and n the total number of rainy days, to solve for P, the probability of rain after K days. As shown in Table 2 the probability after one day of rain is 0.687 as compared with the general probability of 0.585, or an increase of 10 per cent, after 2 days, 0.705, after 3 days 0.718, etc. The results are in general, in close agreement with values at Montsouris and at Lincoln except for the somewhat lower probabilities at the latter station.

TABLE 1.—*The number (S) groups of (k) consecutive rainy days, San Juan, P. R.*

k	1	2	3	4	5	6	7	8	9	10	11	12
S, observed	684	410	253	170	120	89	69	34	32	16	17	41
S, calculated	1,061	623	365	214	125	75	42	25	15	9	5	3
k	13	14	15	16	17	18	19	20	21	22	23	24
S, observed	11	4	4	2	3	3	1	1	1	2	1	0
S, calculated	2	1	0.7	0.4	0.2	0.1	0.08	0.04	----	----	----	----

Also 1 group of 25 days and 1 group of 44 days.

TABLE 2.—*Probability (Pk) of rain when it is known to have rained the (k) preceding day, San Juan, P. R.*

k	Pk	k	Pk	k	Pk	k	Pk
1	0.689	12	0.771	23	0.90	34	0.90
2	.705	13	.79	24	.90	35	.90
3	.718	14	.82	25	.90	36	.90
4	.724	15	.82	26	.90	37	.90
5	.728	16	.82	27	.90	38	.90
6	.732	17	.81	28	.90	39	.80
7	.740	18	.82	29	.90	40	.80
8	.761	19	.85	30	.90	41	.80
9	.759	20	.85	31	.90	42	.70
10	.772	21	.85	32	.90	43	.50
11	.764	22	.86	33	.90	------	--------

In Table 3 is the coefficient of persistency for the several months, and year. The ratio: $-R=\frac{P'-P}{1-P}$ is used where P is the general probability, P' the probability after one day of rain. In solving, R would equal 0 if there were no influence from rain the day before and equal to 1 if the rain of the preceding day assures another rain. From the values derived we obtain an indication of the relative influence of persistence in the several months and seasons. The most marked effect from this factor is shown for the month of March with the value 0.35 as compared with 0.08 for July. Thus in March the probability for a second day of rain is 18 per cent greater than the general probability, while in July the difference is negligible, being but 2 per cent. Secondary maxima of 0.34 and 0.32 occur in November and May, respectively, in consonance with a 12 to 15 per cent difference between the general probability and the probability after one day of rain. In the months of June, July, and August we find there is the least effect from persistency, especially marked in July when it is but one-fourth of the March, May, and November values. To trace the cause of this variance it is indicated in large measure by the absence of temperature contrasts during the summer period and the more local character of the precipitation. At Lincoln the coefficiency values also reveal a minimum influence during the summer period. At Montsouris the differences between the several months are less although the highest values occur in May, February, and November, very nearly the same grouping as at San Juan.

TABLE 3.—*Monthly and annual values of the coefficient of persistency R*

SAN JUAN, P. R.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
P	0.640	0.524	0.487	0.475	0.536	0.568	0.661	0.607	0.587	0.604	0.633	0.700	0.586
P'	.718	.654	.664	.578	.683	.640	.689	.672	.665	.694	.757	.773	.687
R	.22	.26	.35	.20	.32	.17	.08	.17	.19	.23	.34	.24	.24

MONTSOURIS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
P	0.582	0.558	0.551	0.530	0.499	0.476	0.470	0.456	0.452	0.529	0.574	0.618	0.525
P'	.708	.760	.713	.693	.742	.650	.679	.641	.649	.688	.762	.767	.704
R	.30	.46	.36	.35	.49	.33	.39	.34	.36	.34	.44	.39	.38

LINCOLN

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
P	0.37	0.38	0.37	0.48	0.49	0.50	0.42	0.42	0.38	0.33	0.29	0.30	0.394
P'	.52	.56	.52	.60	.60	.59	.50	.46	.53	.54	.52	.31	.540
R	.24	.29	.24	.23	.22	.18	.14	0.7	.24	.31	.32	.30	.241

In summarizing, it is found that the probability of rain at San Juan is definitely influenced by the weather of the preceding day, that this influence is found to persist for a considerable period without break and that given a longer period of observations it seems justifiable to assume that the probability will continue a gradual increase throughout. It is found also that there is some variation in the effect of persistency as regards the several months and seasons and it is indicated that this difference is largely dependent upon local climatic characteristics, with a generally minimum value occurring during the summer period of slight temperature contrasts and the frequently local type of rainfall.